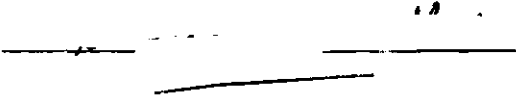


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DETERMINATION OF CRITERIA FOR THE SELECTION OF THE OPTIMUM  
MATERIALS HANDLING METHOD FOR ANY GIVEN INDUSTRY  
IN THE RECENTLY EMERGING ECONOMIES OF THE WORLD

A THESIS

Presented to

The Faculty of the Graduate Division

by

Feroze Nariman Dallas

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in the School of Industrial Engineering

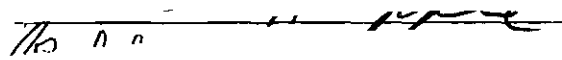
Georgia Institute of Technology

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## SUMMARY

This thesis proposes a set of qualitative criteria in conjunction with a quantitative evaluation for each of these in order to establish guidelines towards seeking an optimum materials handling method for any given situation in the developing countries of the world.

The choice between labor-intensive and capital-intensive methods of materials handling is critically reviewed and specific norms have been developed to spotlight the importance of certain imperative factors of consideration--especially those signifying the influence of political, sociological, topographical, climatological, and cultural changes in seeking a feasible solution to the problem.

In order to arrive at the selection of an optimum handling method, accent has been laid not only on the human, environmental, and the production factors, but also on the concept of productivity and its domineering influence on the overall structure of the problem.

An economic appraisal is made between a developing and an advanced economy on the basis of comparing the relative purchasing powers of the two economies--India and the United States, respectively.

Through a process of subjective evaluation, different levels of mechanization have been established for several developing countries, based on previously recognized levels.

The analysis of the quantitative criteria clearly shows that it is uneconomical for emerging economies to pursue a policy of intensive and indiscriminate industrialization.



## CHAPTER I

### INTRODUCTION

Materials Handling, like many other fields of activity, has seen many changes. Over the many years there has been continuous progress in the evolution of new methods and better handling practices in the science of product-flow.

As the pace of progress in methods and ideas began to develop, there grew a certain basic urge towards modernization, the impact of which was felt throughout the materials handling world. In fact the enthusiasm in the pursuit of advanced techniques has been so very dominant, that it has not been uncommon to see improvements being advocated more through sophistication than through simplicity.

Hence there arises the need for arriving at criteria that would lead to the selection of optimal solutions to materials handling problems, as a guide to the presently progressing countries of the world.

The developing economies face a totally different kind of a challenge--one which lies embedded in the complexity of political, social, cultural, topographical, climatological and labor problems. The continuing advancement of these emerging nations does not lie so much in the race to intensify industrialization as it lies in the judicious application of concepts and techniques.

This thesis attempts to explore, identify, and establish a set of criteria as a basis for putting forth systematic guidelines in ar-

iving at the best attainable solution for a given situation.

Throughout this thesis, the words "developing economies" and "emerging economies" have been used interchangeably, and therefore hold the same connotation.

## CHAPTER II

### LITERATURE SURVEY

An extensive research of available literature was made in an effort to evaluate any previous work done towards the determination of criteria leading to the selection of the optimum handling method for any given industry in the emerging economies of the world.

The search indicated that while the specific problem had hitherto not been studied, some literature existed from which ideas could be gathered and compounded in order to develop the facts of the problem.

By far most of the material on the selected topic came from several UN Publications (11) which describe the constructive efforts of the world's many emerging economies under the context of their diverse socio-cultural and economic backgrounds.

Keyfitz (8) stresses the vitality of the demographic factors and their influence on the growth and development of the South and Southeast Asian Economies. Thompson (15) associates the factors of economic progress and development with a planned growth of an economy. He underlines the importance of the labor concept on the technological advancement of a nation and examines its influence in accounting for a country's industrial growth.

A publication of UNESCO, written under the co-editorship of Egbert de Vries and Iose Medina Echavarria (13), details the role of social factors on the economic development of the Latin American Conti-

ment and the importance of elements such as work and entrepreneurial capacity, social mobility, economic and political rationality, and the political effects of development are also reviewed. Due focus is given to the strategy of improvement that could be promoted by the pursuit of a programmed economic development. Accent is also laid on the impact of education and research for further development.

In another UNESCO publication under the editorship of Philip M. Hauser (16), the effects of the demographic situation and its characteristics are reviewed with the Latin American Continent in the forefront.

Special emphasis is directed towards the question of Management-Labor Relations in the following abstract (16).

Firstly, there is a radical disparity in income, education, social status, social origin, authority, etc., between the employer class and the working class. This is common in newly developing countries and areas. . . .

Secondly, it is common knowledge that the fate of unions varies considerably according to the political régime, although they are themselves usually predominantly political. . . .

Lastly, there is a point of some consequence for social policy. Labor unions may be very effective way for channelling the protests that must inevitably arise with radical social transformation. They may serve as effective agencies of positive social participation, just as professional societies do.

The relationship of a nation's political stability with its economic growth is highlighted by Tangri (14). He points out primarily to the ensuing economic frustrations--(viz) unemployment, underemployment, and misemployment--and their role in retarding constructive progress.

Johnson (7) refers to the complex structure of the problems of

developing countries and alludes to the factor of slow progress to the ills of irrational planning, inherent poverty, improper trade development, and inflexibility towards the processes of economic change. He stresses on the basic change in outlook as being essential to progress.

Nath (9) speaks of the importance of correct planning and growth in the development of the Economy of India. In order to create a healthy outlook towards industrialization through the optimization of techniques and processes, he emphasizes the need on the part of the working force to develop the right kind of mental attitude. He also underscores the importance of greater enthusiasm and better motivation for the success of industrialization. He refers to the damaging influences of bureaucratic practices and laissez faire policies, which directly tend to arrest the development of better methods and practices through the pursuit of inert ideologies and due to extensive time lags in decision-making.

Yah (17) outlines the importance of the social factors in leading to the planned growth of the Malayan Economy. The author claims that "An economic upsurge cannot be brought about unless the institutional claims that fetter the energies of the rural people are broken and new ideals and ideas, more conducive to rapid economic and social growth, are substituted in their place."

Onslow (2) details the multiplicity of factors that play a dictating part in the economic development of a country.

Economic development does not depend wholly, or even largely, upon governmental action. There are many factors, such as climatic influences, the availability of natural resources, the economic qualities of the population and the prevalent customs and social institutions, which are only marginally susceptible

to official action. It is not coincidental, for instance, that almost all the less developed countries lie in the tropical or semi-tropical regions of the world. There are definite limits to the pace and extent of material advance in such countries, and these cannot be overcome either by the assumption by government of comprehensive powers over the entire economy, or by accepting the income aspirations of developing countries as a categorical imperative.

Pepelasis, Mears, and Adelman (10) stress the utmost significance of economic growth as being the most imperative factor in the development of the world's emerging economies. They claim that economic growth cannot take place unless the rate of growth of total output exceeds the rate of population increase. The importance of human resources, capital formation, the impact of technology and socio-cultural factors are adequately borne out.

## CHAPTER III

### DIFFERENTIATION BETWEEN AN ADVANCED ECONOMY AND AN EMERGING ECONOMY

#### Advanced Economy

An advanced economy is essentially one which is technologically well developed, has a high standard of living, and is extensively industrialized.

#### Emerging Economy

An emerging economy is one in which industrial progress is only recent (since World War II), where poverty is imminent and where the standard of living is low on account of the ignorance of the masses, lack of proper training facilities, unemployment, and overpopulation.

Table 1 lists the relevant statistics on most of the emerging economies of the world.

Table 1. Selected Economic Data for Low Income Countries\*

Continent	Country	Area		Population			Literacy Percent
		National Territory in (1000 sq miles)	Agriculture Land as Per- cent of National Territory	Total Million	Current Annual Rate of Growth (Percent)	Density per Sq Mile	
Africa	Algeria	920	19	11.0	2.5	12	10-15
	Egypt	386	3	29.8	3.0	77	30
	Ethiopia	457	67	20.2	1.4	44	5
	Ghana	92	22	7.7	2.6	84	20-25
	Kenya	225	10	9.4	3.0	42	20-25
	Mauritania	419	1	0.8	1.4	2	1-5
	Morocco	171	35	13.4	3.1	78	10-15
	Sudan	967	12	13.5	2.8	14	10
	Tunisia	48	40	4.7	2.5	98	25-35
Asia	Afghanistan	254	19	14.4	2.0	57	5-10
	Burma	262	13	24.7	2.1	94	60
	Ceylon	25	26	11.3	3.0	452	70-80
	India	1260	54	490.0	2.4	389	24
	Indonesia	576	12	105.5	2.3	183	45
	Iran	636	11	23.4	2.5	37	15-20
	Iraq	173	35	7.1	2.0	41	20
	Israel	8	53	2.6	3.5	325	90
	South Korea	38	21	24.7	2.9	650	85
	Malaysia	128	17	9.4	3.1	73	35
	Nepal	54	28	10.1	2.0	187	5-10
	Pakistan	365	27	113.8	2.6	312	20
	Philippines	116	37	32.3	3.3	278	72
	Saudi Arabia	618	1	6.5	1.0	10	5-15
	Taiwan	14	24	12.9	2.8	921	75



Table 1. Selected Economic Data for Low Income Countries (Continued)

Continent	Country	Area		Population			Literacy Percent
		National Territory in (1000 sq miles)	Agriculture Land as Per- cent of National Territory	Total Million	Current Annual Rate of Growth (Percent)	Density per Sq Mile	
Asia cont.	Thailand	198	20	31.4	3.1	159	70
	South Vietnam	66	35	16.1	2.8	244	40-50
Latin America	Argentina	1084	52	21.7	1.7	20	91
	Bolivia	424	13	4.2	2.3	10	32
	Brazil	3280	15	82.2	3.1	25	61
	Chile	286	8	8.5	2.3	30	84
	Colombia	440	17	17.0	2.9	39	62
	Costa Rica	20	20	1.4	4.1	70	88
	Ecuador	112	12	5.0	3.0	45	68
	El Salvador	8	58	2.9	3.2	362	48
	Guatemala	42	19	4.4	3.1	105	30
	Haiti	11	31	4.6	2.1	418	10
	Honduras	43	38	2.3	3.1	53	45
	Jamaica	4	43	1.8	2.6	406	85
	Mexico	760	48	40.9	3.2	54	71
	Panama	29	18	1.2	3.0	41	78
	Peru	514	11	11.7	3.0	23	61
	Trinidad-Tobago	2	35	1.0	3.0	483	80
	Venezuela	352	25	8.8	3.4	25	80
Europe	Greece	51	68	8.6	0.9**	169	82
	Portugal	35	54	9.1	---	261	--**

Table 1. Selected Economic Data for Low Income Countries (Concluded)

Continent	Country	Area		Population		Density per Sq Mile	Literacy Percent
		National Territory in (1000 sq miles)	Agriculture Land as Per- cent of National Territory	Total Million	Current Annual Rate of Growth (Percent)		
Europe cont.	Spain	194	83	31.3	---**	161	---**
	Turkey	301	70	31.1	2.5	103	44

\* Source: How Low Income Countries Can Advance Their Own Growth.  
Printed by the Committee for Economic Development, New York, N. Y., September,  
1966.

\*\* Data not available.

## CHAPTER IV

### THE PROBLEMS OF THE EMERGING ECONOMIES

The study of the present day world reflects a coexistence of conflicting ideologies, wherein unlimited affluency lies interspersed with outright poverty.

The characteristic economic imbalance in nature has been instrumental in accounting for the disparity in the materialistic fortunes of the different countries of the globe, with the result that some nations have had more than their share of good fortune.

The emerging economies were for a long time exposed to the intrigues and maladies of politics, socio, and cultural changes. Their experiences have undeniably revealed that in order to sustain, stabilize, and spur themselves towards more efficient goals of endeavor, a methodical and a rationalistic approach would have to be pursued in seeking solutions to pertinent questions.

Plagues, poverty, and prejudice have a devastating effect on the healthy development of many growing nations, with the result that the usage of better practices has often been suppressed through blind addiction to outmoded beliefs, orthodox philosophies, and age-old practices.

The following global map features the different emerging economies of the world.



Figure 1. Map Showing the Emerging Economies of the World

## CHAPTER V

### THE ASSESSMENT OF ECONOMIC GROWTH AND INDUSTRIAL DEVELOPMENT

#### Dollar Comparison versus Purchasing Power

Figure 2 shows the Per Capita Net Incomes of the developing economies of the world, from which it can be seen that there is a general trend in the distribution of net incomes.

As can be seen from this figure, the Per Capita Net Income is the lowest for South and Southeast Asia and for a major part of Africa, while it is the highest for the Soviet Union and in certain specific regions of the Latin American Continent.

On a second look it will be found that in order to obtain a true objective evaluation of the economic disparity between the different developing economies, a dollar comparison would not provide an accurate evaluation as only a very superficial and a broad indication can be obtained from it.

Hence, in order to obtain a reliable assessment of the economic patterns of the different developing countries, it will be essential to apply another basis for comparison--(viz) purchasing power.

#### Comparison of Purchasing Power of the Indian and the U. S. Economies

The following tabulation draws a comparison between a developing economy and an advanced economy with regard to the concept of purchasing

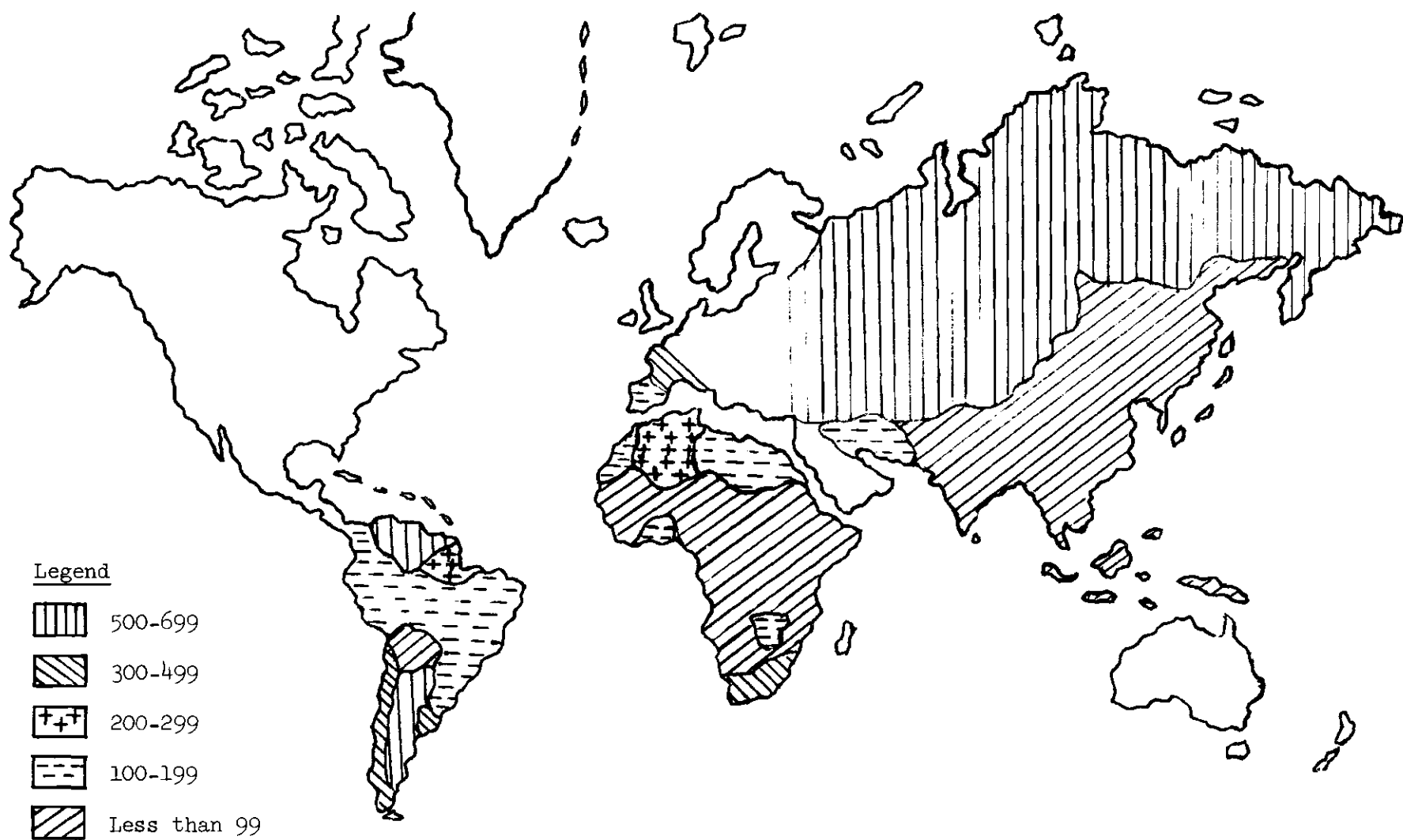


Figure 2. Map Showing Per Capita Net Incomes of Developing Economies in U. S. Dollars (1956-1958)

Source: United Nations Statistical Office, Per Capita National Income Annual Average, 1956-8, New York, 1960.

Table 2. Examples for Comparison of Purchasing Power of the Indian and the U. S. Economies

Commodities	Countries of Comparison	
	India	U. S. A.
	Lowest Rate: ~ Rs. 200 per month or Rs. 0.96/hour or 1.6 P./min Total hours per wk: ~ 48	Lowest Rate: ~ \$1.40 per hour or \$0.023/min
	Exchange Rate: ~ Rs. 7.50 = \$1.00	
1 dozen eggs	Rs. 3.60	\$0.65
Time required for purchase	3 hours 45 minutes (8.04 times more)	28 minutes
Inland letter	15 P.	\$0.05
Time required for purchase	9.4 minutes (4.48 times longer)	2.1 minutes
Shoes	Rs. 40	\$15.00
Time required for purchase	41 hours 40 minutes (3.82 times more)	10 hours 44 minutes
400 gm bread loaf	57 P.*	\$0.22*
Time required for purchase	35.6 minutes (3.75 times longer)	9.5 minutes

\* Equivalent price obtained on a pro rata basis from the price of 13 oz. loaf which is taken to be 20 cents.

Note: (i) The prices mentioned above represent those prevalent in the two countries in November 1967.

(ii) The wage rate in India consists of a basic pay and a dearness allowance. The latter changes according to the cost of the living index. The figure of Rs. 200/month is computed by taking a basic pay of Rs. 30/ and a dearness allowance of Rs. 170/.

power. The countries featured are India and the United States, respectively.

As can be seen from the comparison table, the difference in the working hours required to purchase the different commodities is indicative of the disparity in the economic structure of the two countries.

### Choice of Materials Handling System-- Capital-Intensive versus Labor-Intensive

A question that generally confronts developing countries is whether it would be profitable to install a handling system that is capital-intensive or to install one which is labor-intensive.

In answering this question, the following two objectives must be considered:

1. the system should be such that it results in a low cost per unit of output, and
2. the system should optimize the use of the skill of operators.

The determination of the method that would give the lowest cost per unit of output depends on factors such as, cost of labor, scarcity of skilled labor, availability of capital, and the cost of capital.

Handling Systems that are labor-intensive provide more employment per unit of product than do capital-intensive methods. A majority of the developing economies have an acute shortage of capital but enjoy an abundance of low-cost labor. In such cases it would be both prudent and profitable to strive for labor-intensive methods in order to maximize the use of unskilled labor and also to economize on the limited amount of available capital for securing a well balanced economic growth.



Capital-intensive methods can be beneficially applied in those countries where the labor wage rates are high and capital is available in plentiful proportions. Obviously, such countries are the industrially advanced economies like the United States, Germany, France, Great Britain, Canada, and a few other nations in Western Europe.

Sometimes it may become difficult to choose between labor-intensive and capital-intensive methods, when the choice has to be made from a large variety of methods. It may happen that the choice of a system of materials handling may be dictated by the nature of the technology or by the size of the market in such a way that a capital-intensive process may become much more productive so as to give substantially lower unit costs than the only alternative, labor-intensive, process.

Hence, the goal of selection should be directed to choose that combination of labor and capital that gives the lowest cost under a specific context of consideration.

The United Nations Department of Economic and Social Affairs points out that (12)

Capital-intensive processes are often identified with industrialization and have a prestige appeal. Engineers often have a psychological bias in favor of such techniques. . . . Business managers often prefer them in order to avoid irksome labor problems. The constellation of forces operates against the use of the economically correct factor proportions.

P. C. Alexander (12), a leading economist, points out in his paper on the aspect of "Modernization of Small Scale Industry in India," the danger in going for accelerated modernization. He states that an injudicious pace of modernization could seriously jeopardize the social order of any country and could lead to "serious disturbances" culminating

out of the fad of "modernization at all costs."

Other economists have also categorically maintained the importance of pursuing labor-intensive methods in underdeveloped economies. They have suggested a gradual transition in methods and practices, as rapidity of change could well spark off sudden stresses and strains in an economy's socio-structure.

### Investment in Expansion Approach versus Increased Productivity Approach

Advancement in industrial development can be attained through either (1) investment in expansion, or (2) investment in increased productivity.

#### Investment in Expansion

Developments resulting from investment in expansion represent the most common cause of action through which progress has often been sought. This is also the most direct but expensive way to develop a plant or a system, since the installation of better equipment through modern facilities invariably promotes a more efficient operation in the functioning of an industrial organization.

There was a time when the criterion of cost-control through cost-consciousness invited little attention and very often the influence of cost factors on competitive pricing was overlooked in the light of the prevalent obsessions towards earmarking high investments for expansion programs.

While the policy of industrial development has not proved to be damaging to the growth of the affluent advanced economies, the approach

is nevertheless not without its risks. Although the use of advanced technology is capable of endowing certain benefits to an organization through an increased outflow of production, they may not necessarily be attained at controlled costs. As a matter of fact, it always takes an appreciable time to recover capital invested in expansion, which can prove to be fatal to the growth of enterprises in less developed economies. In addition, the factors of unforeseen equipment failure and equipment obsolescence also have to be considered.

The concept of investment for expansion can only be justified if it is aimed towards obtaining maximum productivity.

#### Increased Productivity

Productivity has been defined as the ratio of output attainable to the amount of resources directed to secure the output. Productivity therefore deals in showing the interrelation between output and input.

Since productivity is a ratio, there exist two methods to maximize it. The more common approach has been to increase the output for a relatively lower increase in the input. However, productivity can also be substantially boosted through the reduction of the input resources while maintaining the original level of output. It is this latter interpretation of productivity which is of importance.

The enterprises in emerging economies can ill afford to raise their output levels through increased inputs, as limited finances impose severe limitations on the size of investment. Hence, their efforts should be oriented so as to secure the fullest maximum utilization of the existing plant and equipment. This would also lead to an effective check on waste, as unnecessary expenses would be eliminated through

proper scientific planning and control.

Such a process for development would pave the way for obtaining increased productivity not only through cost reduction, but also through the better use of existing installations, through the skillful application of production facilities, and through a thorough understanding of the human element involved. It may be mentioned, however, that the human aspect of considerations is very often overlooked in equipment selection.

The following figure shows the cycle of low productivity. Here low productivity directly results in the acquisition of a low income which in turn accounts for decreased earnings. These in consequence lead to lower savings which reflect in a dearth of capital. This leads to the concept of low productivity again--thus completing a cycle.

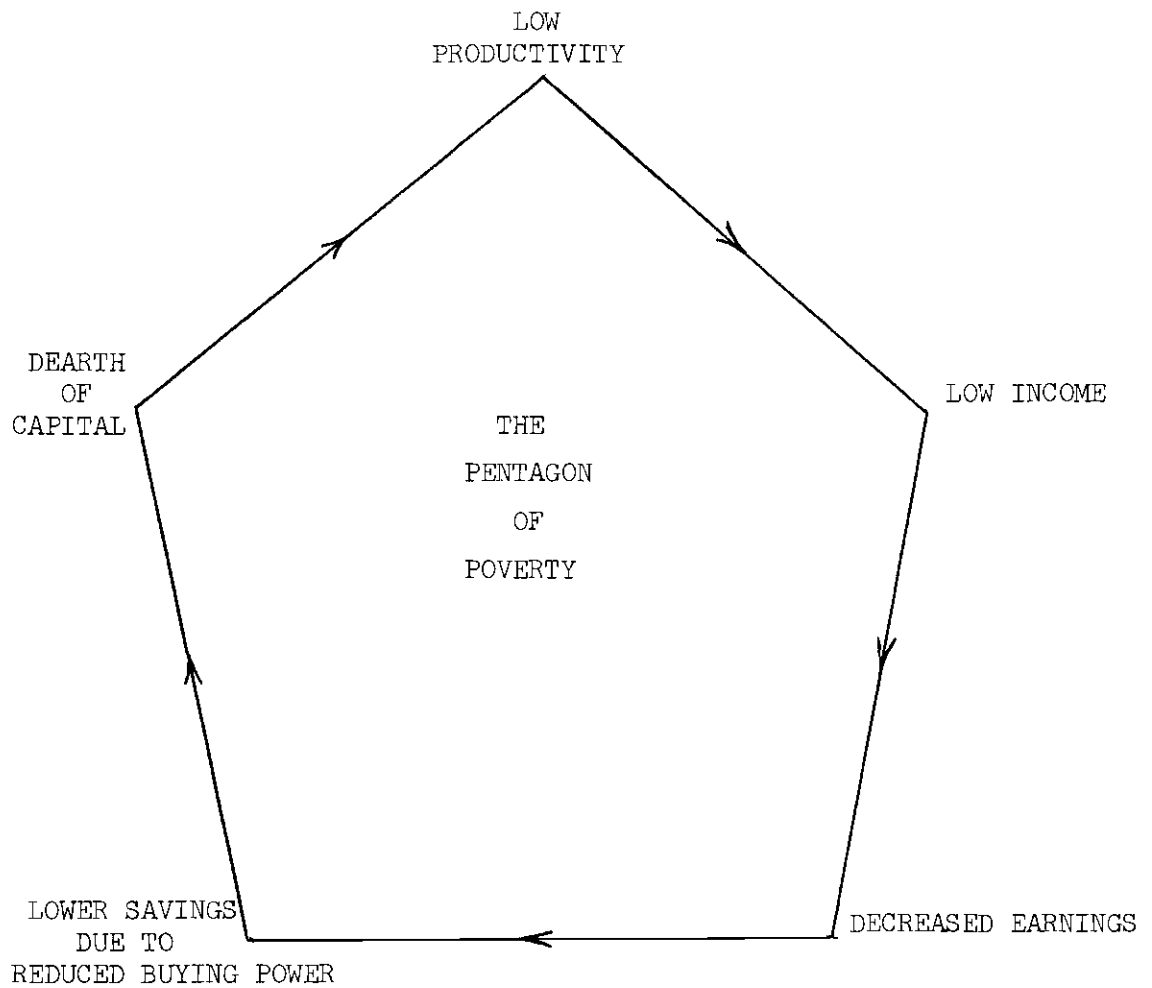


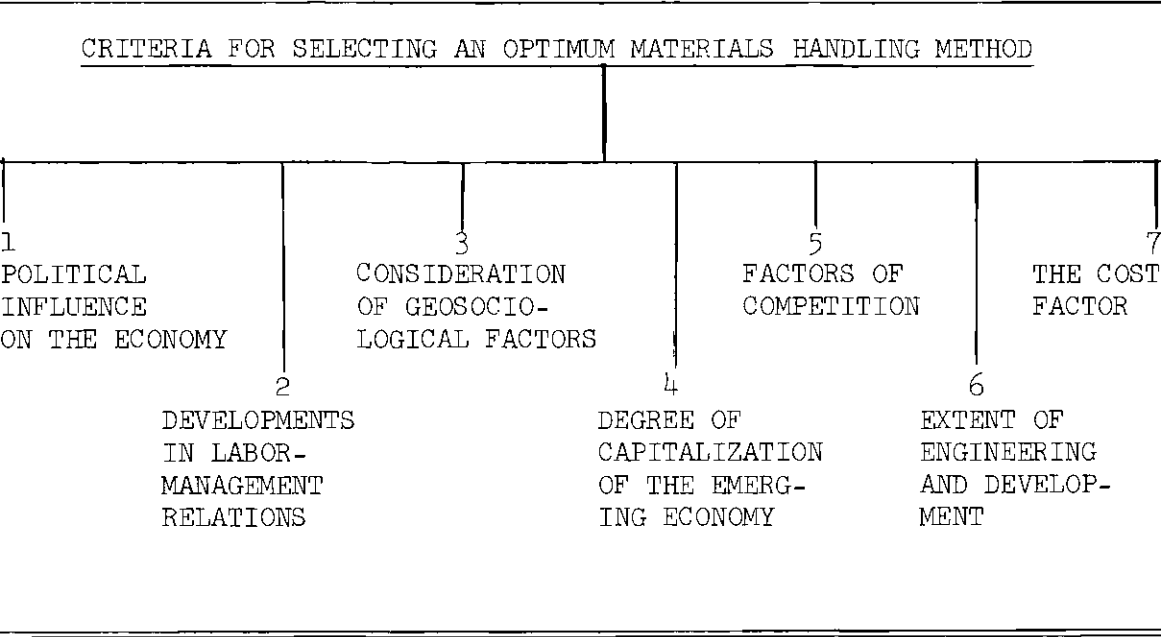
Figure 3. The Cycle of Low Productivity

CHAPTER VI

CRITERIA FOR SELECTING AN OPTIMUM MATERIALS HANDLING METHOD

The following factors represent the criteria which must be considered for the selection of an optimum materials handling method in the recently emerging economies of the world.

Table 3. Criteria for Selecting an Optimum Materials Handling Method



## CHAPTER VII

### QUALITATIVE REPRESENTATION OF CRITERIA

#### 1. Political Influence on the Economy<sup>\*</sup>

This is the most important factor to be taken into account.

Experience has shown that the political barometer of a country sets the pace for the development or the retardation of the living standard of its population. Stability of a country's political system is generally indicative of progress.

A progressive nation will have a forward-minded government that will be continually conscious of its development, whereas an instable political system would jeopardize the chances of a planned constructive growth, with the result that no specific improvements can be attained. Thus, the policies and the outlook of a government form major elements for consideration on the overall impact of the political influence on the economy. Further, in order to spur the pace of industrialization through the economic growth of private enterprise, government should be able to solicit an adequate amount of entrepreneurial interest and faith in its political system.

Finally, a government should have the ability to secure technical aid for itself from other advanced countries, in case its targets for progress cannot be reached on account of scarce resources and due to

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<sup>\*</sup>For convenience of reference, the sections of this thesis are numbered to correspond with the numbers appearing in the accompanying tables.

the limitations of the proper technical know-how.

## 2. Developments in Labor-Management Relations

The role of labor in exerting a domineering influence on many enterprises is well known. The impact of labor unions and their increasing influence on management have sizably helped the working force to consolidate its bargaining power.

The problem of population explosion has been one of the main sources for unemployment and this has been chiefly responsible in promoting an irresistible urge on the part of labor leaders in developing countries to suppress new practices in handling methods that have led to the decrease in employment. The problem of unemployment in particular has been one of growing concern in the developing countries, since it has in a major way been responsible for arresting the pace of progress and prosperity through the inadequacies of education and training.

Closely related with the problem of unemployment is that of underemployment, wherein the services of labor are insufficiently utilized for productive work. A study was made by the Food and Agriculture Organization of the United Nations with regard to the aspect of underemployment and the following finding is of note (12).

According to an estimate by the Food and Agriculture Organization, effective unemployment is barely higher, and sometimes lower than 50% of the available labor force in rural areas in parts of Asia, Southern Europe, and Morocco. Several hundred million men could devote at least one hundred days' work a year to Capital Investment Projects.

Underemployment in a developing country is unavoidable if job opportunities are to be created for the unemployed millions of the less developed nations of the world.



Every developing economy must follow a judicious policy with regard to the degree of mechanized handling it should incorporate in its industries as against manual methods, and this would in itself be dependent on the prevailing attitude of both the labor and the management under the broad context of the economy as a whole.

Hence, attempts at rapid modernization by developing countries through intensive mechanization and/or automation would be most undesirable, since the same would introduce labor problems. The choice of selecting the most economic handling method for a specific country is therefore of greater importance than choosing one which is most modern and mechanized but is essentially incompatible with the economics of the situation.

Another essential concept deals with the governmental attitude towards labor-management relations. The present governmental philosophy in many developing economies--notably Asian Economies--is to support the labor slant and sentiment at extensive sacrifices to the interests of the management. This is perhaps not altogether wrong since the governmental philosophies of many developing economies are founded on the socialistic pattern of thought, wherein the concept of community betterment sustains over that of monopolistic ventures. This has therefore brought about substantial benefits and privileges for labor in areas where once management pursuits went unchecked and unquestioned.

The characterization of this approach has clearly developed two schools of thought in the outlook of the labor and management relations. Labor have increasingly intensified their rights and prosperity at the expense of management, while the management have consistently found

themselves at the losing end of the bargain. Thus, with increasing constraints being cast around the powers of management, it is easy to understand why the modern entrepreneur is rather skeptical to invest capital in industrialization.

The spirit of industrial enterprise has therefore often been prone to managements' doubt and distrust, with the result that the very foundations of economic growth through progressive entrepreneurship have been imperiled.

Another factor much in the foreground of Labor thought is the increased demand for a sufficient living wage. Labor is much lower paid in the developing economies than in the advanced economies and this factor exerts a tangible influence in the continued economic utility of man over machine.

In some of the developing economies, there has been a rather schizophrenistic trend towards seeking progress. Here automation has been indiscriminately introduced and nurtured to coexist with labor, such that there has hardly been any significant decrease in the labor employment. While this approach has benefitted both labor and production statistics, the gains have primarily been attained at the expense of managements' interests. Obviously such an approach has seldom proven to be fruitful.

Finally, the question of training deserves mention. The general standard is set by reviewing the overall level of education of the country's populace and by the nature of technical competence a job demands. This factor exerts a considerable influence in cases of those developing countries which are pursuing an accelerated program of indus-

trialization and where the concepts of training and of technological know-how gather importance.

### 3. The Consideration of Geosociological Factors

These are factors that deal with the combined effects of three principal elements:

- I. Environment
- II. Man
- III. Production factors.

#### I. Environment

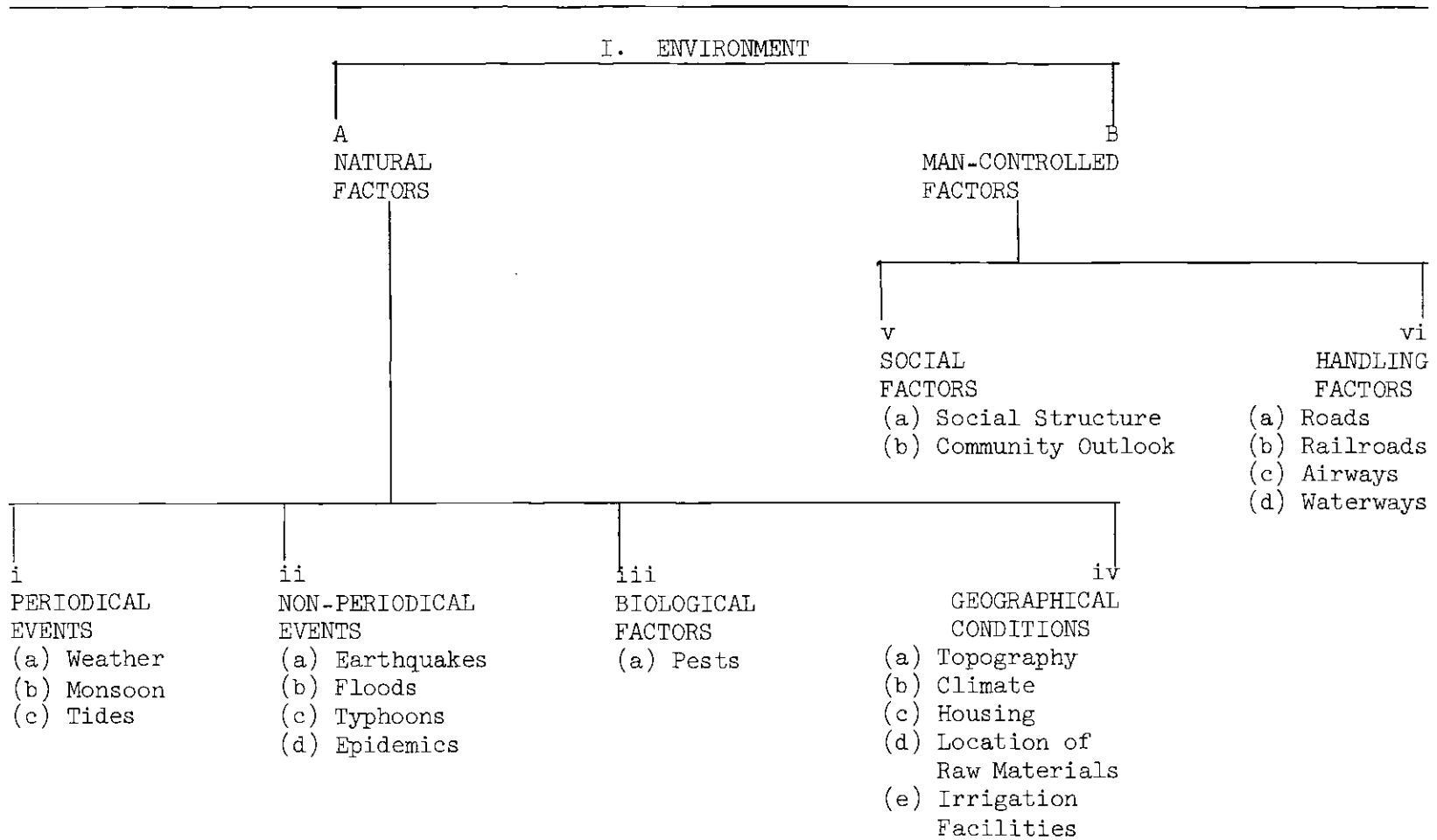
This category consists of the following main factors.

iv (a). Topography. Topography may be defined as the local geography of a country. The importance of topography to a nation's development is a factor that is well acknowledged. The industrial advancement of many countries is to a sizable degree dependent on the geographic location and the surrounding influences of climatological and terrestrial factors. In fact, the terrain of a country generally determines the correct type of handling system that should be used. Mountainous terrains pose many problems and limitations in equipment selection compared to low lands and plains.

Again, the use of high capacity equipment becomes obligatory when materials handling activities are conducted over mountainous regions. This results in not only restricting the range of equipment selection, but also leads towards increased investment.

iv (b). Climate. The influence of climatological factors in deciding upon the choice of the most suitable handling system is known.

Table 4. I. Environment



Source: Adapted from an article on Geosociological Factors by Dr. Lothar Mayer, Professor, Technical University of Berlin.

Climatological extremes have often been responsible for limiting the progressive efforts and activities of developing nations on account of hostile environmental temperatures.

These uncomfortable surrounding conditions tend to decrease the productivity of the workers with the result that these countries find themselves placed in an unfavorable competitive position when compared to those emerging nations which are in the temperate zones.

Psychologically and physiologically speaking, hostile climatic conditions have often induced a sort of happy-go-lucky labor temperament towards work and output. Such an attitude has often been involuntarily motivated by a considerable degree of physical exertion that generally develops under tiring temperatures.

The following points should be borne in mind when selecting a materials handling equipment.

1. Stability of the constructive design of a handling system for efficient operation under a given situation.
2. Surface protection from external factors, such as solar radiation, moisture, pollution, and the effect of micro-organisms.
3. Protection of equipment against changeable natural environmental forces in case it comes in distinct contact with the natural elements.

## II. Man

This category consists of the following main factors.

A (i). Age. The concept of average age is of importance. However, what is of most significance is the percentage of people within the range of the "employable or the working age."

Table 5. II. Man

II. MAN			
A	B	D	F
PERSONALITY	PSYCHOLOGY	INTERESTS	PERSONAL EXPERIENCE
(i) Age	(i) Character	(i) Artistic Tendencies	
(ii) Sex	(ii) Temperament	(ii) Creative Activities	
(iii) Disposition	(iii) Motivation	(iii) Ambitions	
C	E	G	
PHYSIOLOGY	INTELLIGENCE	QUALIFICATIONS	
(i) Strength	(i) Knowledge	(i) Aptitude	
(ii) Endurance	(ii) Philosophy of Life	(ii) Attitude	
(iii) Resistance		(iii) Training	
		(iv) Imagination	
		(v) Responsibility	

In some of the less developed economies--predominantly the nations of Latin America--a majority of the population is below its teens. Besides, with the advancement of science and hygiene, there has been a significant decrease in the mortality rate, with the result that the average life span has shown a steady rise.

These factors have played a vital part in creating specific development problems for this and other economies through an increase in the number of those citizens who are of the pre-employment or the post-employment age. The former, being young, are inexperienced, while the latter have already expended their service life on account of their advanced age.

Thus, a country's progress would be much dictated by the ratio of its working populace to its non-working populace. The greater the ratio, the higher would be the prospects of securing a planned industrialized growth through the effective utilization of man-power.

G (iii). Training. The importance of raising the level of skills through technical training is vital to the growth of an emerging economy, if the installation of industrial plants and equipment is to be a success.

In fact, training becomes a pre-requisite to the development of competent and qualified operators. It is also a primary tool that accelerates industrial improvement.

The basic principles of technical training for the promotion of skills are as follows (12).

1. The objective should be to train as many people as possible, as quickly as possible (without impairing the quality of the instruction) and as effectively as possible; in other words

to concentrate on mass effect, speed and yield.

2. Training should be linked with the national development plan and in particular with the assessment of manpower needs, so as to meet the specific requirements for skill.

3. It should be flexible to allow for changes in the pattern and tempo of production, and for technological advance.

4. It should be regarded as a continuous process, linked with education on the one side and with the place of work on the other.

5. The concept and purpose of industrial training should command the widest possible support of the whole community.

### III. Production Factors

The study of ergonomics is of particular relevance in the developing countries of the world, especially since it covers the factor of work conditions.

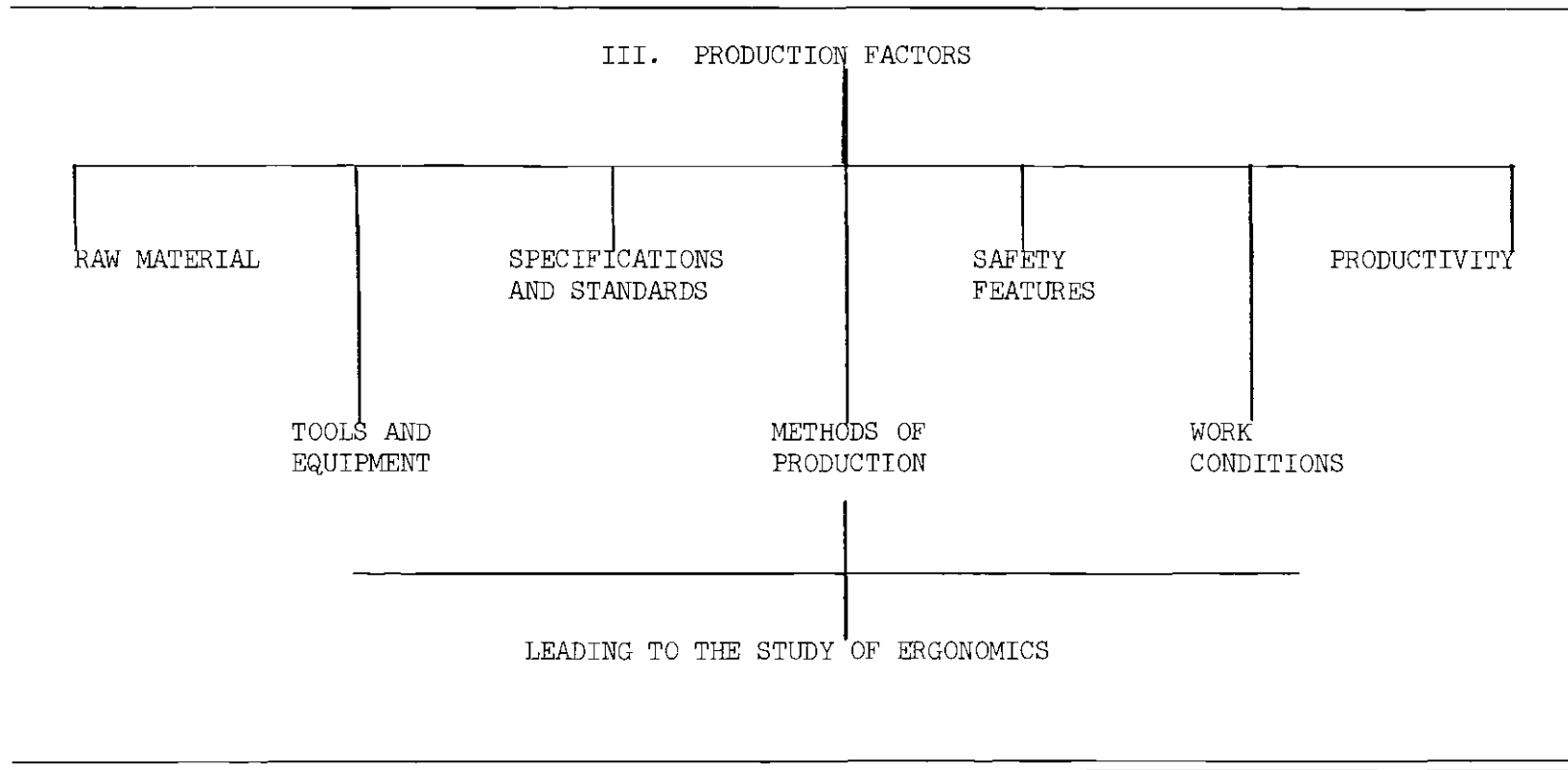
Ergonomics (12) has been defined as "the study of the relation between man and the environment in which he works, particularly the application of anatomical, physiological knowledge to the problems arising therefrom."

Ergonomics helps in an efficient design of equipment in accordance with the local circumstances, so as to improve equipment operating conditions which would lead to the minimization in errors of operation. This would help in not only increasing the overall efficiency of operation, but it would also lead to reduced fatigue, improved safety, and speeded output without any impairment in the quality of work. It also leads to the reduction in the time required for vocational training.

Thus, ergonomics can contribute significantly towards efficiency, safety, and productivity in the newly developing countries through the correct design of plant and equipment.



Table 6. III. Production Factors



#### 4. The Degree of Capitalization of the Emerging Economy

The technological advancement of the less developed nations has often been slow in contrast with that of the advanced economies and this has notably been due to the economic insufficiencies and poverty of the developing nations. Moreover, poor strategies in effort-orientation and monetary investment have made it considerably difficult for developing countries to effectively embark on a rapid industrialization program.

The chief governing factors that account for the degree of capitalization of a developing economy are as follows.

##### i. The Degree of Industrialization

The extent of a country's progress and industrial accomplishment are assessed by the following three main factors.

- (a) The present degree of industrialization.
- (b) The potential for further industrialization.
- (c) Planning for future industrialization.

##### ii. Relative Industrialization of an Economy with Respect to Neighboring Economies

The concept of relative considerations is important here. The economy of a developing nation would in a way depend on the extent of solvency or bankruptcy of the neighboring economies.

A poor economy may be comparatively better off in its structure when viewed against the background of poorer ones. For example, the Spanish Economy, though poor when compared with other economies in the Western Hemisphere, is relatively better off than the currently emerging nations of Africa.

This would mean that it would be more feasible to introduce tech-

nological developments in materials handling in Spain than in the less developed African Economies.

iii. The Financial Position of the Economy

The entire foundation of a country's industrial progress and prosperity can be explained by the following factors.

(a) The degree of trade between the economy and the other countries of the world.

(b) The amount of capital earned.

(c) The growth of International Credit Balances.

(d) The quantity of gold reserves within the economy.

On examining these factors we can say that the higher the values of these factors the better will be the economic pattern of a country.

Most of the emerging economies, unlike the advanced ones, are essentially poor countries whose currency reserves have

1. substantially dwindled due to pursuit of indiscriminate planning procedures,

2. been mortgaged against international commitments, or

3. had accumulated no reserves to begin with.

Such an overall situation would make it generally inconceivable for developing nations to invest large sums of money in a complex of modern materials handling systems.

Much would depend on the strategy of development and the enterprising ability of developing economies to efficiently direct their efforts so as to maximize their gains.

iv. Long Term Credit through International Aid Programs and Foreign Capital Investment

Foreign Aid in terms of monetary and material help can assist the emerging economies of the world to reorient their industrial practices on sound and systematic lines.

A majority of the U.N. sponsored programs for the allocation of international aid to progressing economies are financed through the following organizations.

- (a) The World Bank
- (b) The Agency for International Development
- (c) The International Monetary Fund
- (d) The International Development Association

These international bodies have already extended financial aid to the emerging countries of Asia and Latin America for their industrial growth and economic progress.

#### 5. The Factors of Competition

The impact of neighboring countries on a developing economy can either be constructive or destructive, depending on certain factors of consideration.

If the surrounding economies are more advanced than the developing country, then the country would have to put in rigorous constructive efforts towards meeting the challenge to progress through keen competition.

If, however, the developing country is situated in a hemisphere where progress is only recently evidenced, then there would hardly be any incentive or stimulus on the part of the developing country to forge itself ahead. This would create a destructive influence on the techno-

logical orientation of the economy, where complacency can stagnate progress.

Another aspect that should be reviewed is that pertaining to the level of local consumption. If the local consumption is slack and the home market poor, then the outlook for survival would be to obtain earnings through export. Here the entire competition concept would have to be studied in conjunction with that of production facilities and only that method of handling should be selected that could be warranted with regard to the anticipated business volume, the delivery dateline, and the earnings envisaged.

In case the demand at home is in itself very high, the cheapest handling method should be selected in relevance with the consistency of the demand and the nature of the local consumption.

#### 6. Extent of Engineering and Development

The degree of engineering and development is one of the major criteria for consideration in appraising the problem.

The primary factor of importance is centered on the orientation of the economy itself--(viz) whether it is agriculturally-oriented or industrially-oriented. In an agriculturally-oriented developing economy, the accent on progress is strictly channelled in the pursuits of agrarian activities and this is often done at the expense of limited advancements in the field of industrialization.

Many underdeveloped nations have been essentially agrarian in their economic structure and it is only recently that they have intensified their endeavors in becoming increasingly industrially oriented.

The economic barometer of a country often depends on the extent of its industrialization.

The more industrialized a nation, the more readily susceptible it would be to the impact of advancement and change. This is because of the fact that the philosophy of intensive industrialization would be more compatible in an industrially developed economy than in a dominantly agrarian economy.

Another factor for review is that of technological know-how. Adequate knowledge of techniques and engineering methods is directly responsible for enabling a developing economy to produce its own machinery and mechanical hardware. This obviously becomes a factor in the progress of an economy, where self-sufficiency and local capabilities in manufacturing make the economy self-dependent.

## 7. The Cost Factor

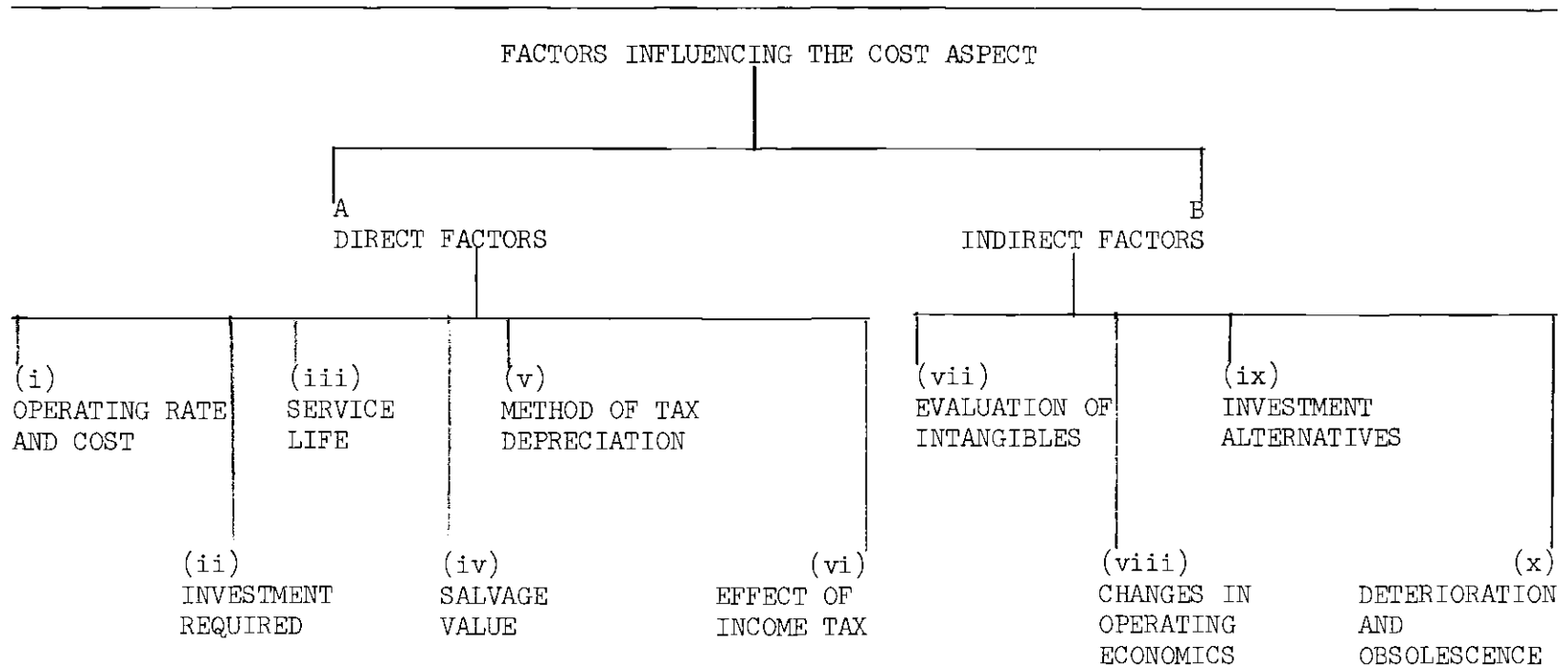
The criterion of cost has universal significance since it provides the most factual yardstick towards assessing the profitability of an enterprise. It is, therefore, natural that cost should be featured as an imperative factor in evaluating the decision as to whether or not the economics would permit the installation of a materials handling system or uphold the manual handling method as the most economical. However, the concept of cost is a complex one.

Table 7 lists the important factors that should be considered.

### A (i). Operating Rate and Cost

Before a materials handling system is introduced in an enterprise, a market research must be made in order to ascertain the advantages and

Table 7. Factors Influencing the Cost Aspect



Source: Adapted from Beggs, H., "Planning and Operating for Profitable Investment Analysis," Increased Profits Through Capital Investment, Eaton Yale & Towne Inc., Chicago, Illinois, 1966.

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disadvantages associated with the system.

The following points should be examined.

- (a) Production Capacity in terms of units handled per hour.
- (b) Overall reliability of the system as assessed through the down-time data collected over a certain period of time.
- (c) Production Time lost due to maintenance down-time and the amount of cost incurred.
- (d) The general morale of the operators as judged by their reactions to the handling system.

The determination of the practical extent and the impact of technological change involved when switching from one system to another is also of note.

A (ii). Investment Required. In case a materials handling system is to be selected for a new industrial enterprise, attention must be given on the construction of the building. Alternatively, the construction of the building should be affected by keeping in mind the requisites and constraints imposed on the structural design by the chosen system of materials handling. Hence, the quantity of investment will be jointly dependent on the equipment and building costs.

A (iii). Service Life. In selecting a materials handling unit, due care must be exercised in choosing that unit which guarantees a longer life of troublefree operation in order to realize a maximum utility for investment.

A critical evaluation must be carried out between long-lived and short-lived alternatives, so as to arrive at the best economic decision. The following points must be considered (6).



1. The fact that money has a time value tends to reduce the attractiveness of distant future services to be received from an asset. For example, with interest at any figure above 0%, it will never pay to double the investment merely to double the prospective length of life.

2. The greater the interest rate or minimum attractive rate of return, the less favorable is the competitive position of the longer-lived alternative.

A (iv). Salvage Value. The choice of equipment selection must be made after a critical appraisal of the salvage value, as would accrue after the completion of the economic life of the equipment.

When selecting between any two given materials handling systems, it would be preferable to select that system which has the higher salvage value, all other factors being equal.

However, the deciding factor of selection should be judged more from the totality of the overall aspects of consideration rather than from the point of view of the salvage value alone, since it would be rather practically improbable to have two systems which feature the same degree of advantages and disadvantages.

A (v). Method of Tax Depreciation. Different developing economies are likely to follow different methods of depreciation in accordance with the prevailing tax laws and, therefore, the best method for tax depreciation would be governed by the nature of the local conditions.

However, it may be worthwhile to note that in the United States the following methods of depreciation accounting are used.

(a) Methods that give a greater write-off in the earlier years of life than in the first year of life.

(b) Methods that give a smaller write-off in the earlier years of life than in the final years.

(c) Methods that give a more uniform write-off throughout the entire service life.

A (vi). Effect of Income Tax. Income Tax, in this context, is assessed on the net gain made in a commercial enterprise. The tax is arrived at after deducting all the company expenses that have been incurred in the process of doing business during a specific time period.

In order to promote economic growth and industrial progress, a government may authorize a certain maximum percentage of tax deduction by way of an Investment Tax Credit. The degree to which this concept is followed in the emerging countries would vary from nation to nation and, therefore, the specific income tax structure of a country should be scrutinized before any investment is made in a materials handling system. The nature of benefits arising out of such an incentive should be examined economically so as to optimize investment possibilities for further expansion.

B (vii). Evaluation of Intangibles. The importance of the correct evaluation of Intangible Factors must be adequately considered before making an investment decision. Intangible Factors are those whose contributing influence in an enterprise cannot be accurately quantified on account of the fact that these cannot be specifically evaluated.

These intangible factors may pertain to the equipment itself, its manufacturer, or a management policy or philosophy (1).

(a) Quality and durability of equipment

(b) Compatibility of equipment with present handling system

(c) Flexibility of equipment in terms of capacity, with changing volume

- (d) Adaptability of equipment to possible future applications
- (e) Ease of availability of equipment and spare parts
- (f) Quality of service available after sale
- (g) Trends in equipment costs over a period in time
- (h) Possibility of future plant expansion
- (i) Manufacturer's reputation
- (j) Labor relations aspects of displaced personnel--labor saving versus labor turnover
- (k) Psychological effects of mechanization and automation of equipment on employee morale
- (l) Financial policies of the corporation

In order to arrive at reasonably reliable estimates in the interpretation of intangible factors, it is necessary to take such estimates from authentic sources so as to minimize the degree of the estimating error. Total omission of intangibles could produce a highly erroneous picture of facts that might well distort an otherwise well planned investment decision.

As will be seen in a subsequent chapter, a quantitative evaluation can be established for each criterion by numerically determining the many intangible factors involved.

B (viii). Changes in Operating Economics. Any investment analysis must consider the possible changes in revenues and operating costs which may occur at a later date. These changes could arise on account of the role played by both controllable and uncontrollable factors. The controllable factors allude to the development of optimum conditions, which when fully realized can substantially decrease the operating costs.

The latter factor may arise due to the enactment of certain governmental statutes which may bring about changes in production schedules and employee recruitment, such that the entire structure of revenues and operating costs might be drastically changed.

Hence, the change in operating economics becomes a factor of considerable significance in the realm of investment decisions.

B (ix). Investment Alternatives. The concept of Investment Alternatives is centered on the economic justification of whether it would be beneficial to invest the available capital in a given materials handling unit, or whether it would be better to direct it into other channels of investment.

At all stages of the critical examination of possible investment alternatives, sufficient accent must be laid on the "money spent to money earned" ratio in order to arrive at a solution where the money ratio is a minimum.

B (x). Deterioration and Obsolescence--its Effect on Revenues and Costs. Before the purchase of a materials handling system can be considered, the effects of deterioration and obsolescence must be surveyed.

It would prove to be highly uneconomical to invest capital in the purchase of such equipment that would deteriorate very rapidly, either due to the action of natural forces or due to the incorrect use of the equipment for performing jobs other than those for which it was designed.

The effect of obsolescence must also be considered in order to appraise its effects on the factors of revenue and cost. In a world of continuous technological change, where research and development constantly create better equipment, it would still be impracticable to accurately

determine the time for obsolescence for any given equipment.

The effective appraisal of obsolescence increases in difficulty where complex handling systems are employed, since the generation of new techniques could totally outdate a relatively recent piece of equipment.

Sometimes, however, it may be possible to roughly approximate the useful life of an equipment or a system on the strength of past accumulated data and experience.

The ability to determine useful life helps in the effective comparison of costs against revenue. This aids in planning production operations so as to secure the maximum possible utilization of a given handling unit through a well-programmed service life.

## CHAPTER VIII

### QUANTITATIVE EVALUATION OF CRITERIA

In order to arrive at some quantitative estimate for ascertaining the potential degree of influence of the different factors constituting the criteria, a system of quantification has been developed through which it is possible to allocate numerical values of importance to each criterion.

The assessment represents a purely subjective interpretation by the writer towards gauging the relative importance of the criteria, and all values featured herein are based on the author's personal opinion and judgment--partly arrived at through personal exposure and partly assimilated from the study of reference publications.

The developing economies are represented by India, Argentina, and Greece, while the United States stands for the advanced economy and is chosen for making the contrast more characteristic. The choice of the developing economies was made to select economies on different levels of development and political structure.

#### Structure of the Quantitative Tabulation

In order to illustrate the method of analysis, let us consider the first criterion--the Political Influence on the Economy, which is tabulated on page 49.

- i. The factors for consideration under this criterion are tabu-

lated in order of decreasing importance such as:

1. The influence of stability of government
2. Policies and outlook of government
3. Entrepreneurial faith in the political system for aiding industrialization and economic growth of enterprises
4. Need of government to secure technical aid for industrialization through international participation.

ii. Next, each factor is given an "importance value" in percentage:

<u>Factors</u>	<u>Importance Value</u>
1	100
2	90
3	80
4	70

iii. The different importance values are then adjusted so as to make the total of the "adjusted importance value" column equal to 100.

$$\text{Adjusted Importance Value} = \frac{\text{Importance Value}}{\text{Total of Importance Value Column}} \times 100$$

<u>Factors</u>	<u>Importance Value</u>	<u>Adjusted Importance Value</u>
1	100	29
2	90	26
3	80	24
4	<u>70</u>	<u>21</u>
Total	340	100

iv. Each factor is then evaluated to determine its specific importance for a particular country. A rating of 100 would indicate that

the factor is of utmost importance. For example, in the case of India we have:

Factors	Importance Value	Adjusted Importance Value	Evaluation Rating
1	100	29	90
2	90	26	100
3	80	24	80
4	70	21	80

This means that, of the above four factors, the second factor, i.e., Policies and Outlook of Government, is the most significant aspect for India but is less important to other countries with which India is being compared.

v. Finally, each factor is weighted in order to obtain a "weighted evaluation rating." This is arrived at as follows.

$$\text{Weighted Evaluation Rating} = \frac{\text{Evaluation Rating} \times \text{Adjusted Importance Value}}{100}$$

The summation of the Weighted Evaluation Ratings for each factor gives the composite Weighted Evaluation Rating for the given criterion under consideration. For example, in the case of India we have:

Factors	Importance Value	Adjusted Importance Value	Evaluation Rating	Weighted Evaluation Rating
1	100	29	90	26
2	90	26	100	26
3	80	24	80	19
4	70	21	80	17
				<u>88</u>

Following the same path, various other criteria have been similarly evaluated as shown in the following tabulations.



# 1. Quantitative Evaluation of the Political Influence on the Economy

No.	FACTORS TO CONSIDER (In Order of Importance)	COUNTRIES UNDER CONSIDERATION									
				INDIA		ARGENTINA		GREECE		U. S. A.	
		Importance Value	Adjusted Importance Value	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating
1	The influence of stability of government	100	29	90	26	100	29	90	26	30	9
2	Policies and outlook of government	90	26	100	26	90	23	80	21	50	13
3	Entrepreneurial faith in the political system for aiding industrialization and economic growth of enterprises	80	24	80	19	80	19	70	17	10	2
4	Need of government to secure technical aid for industrialization through international participation	70	21	80	17	90	19	80	17	10	2
		340	100	88		90		81		26	

# 2. Quantitative Evaluation of the Development in Labor-Management Relations

1	The impact of unemployment	100	22	100	22	50	11	60	13	60	13
2	Governmental attitude	90	20	95	19	60	12	70	14	70	14
3	Labor attitude	80	18	90	16	70	13	60	11	80	14
4	Management outlook	70	16	95	15	60	10	60	10	70	11
5	Labor remuneration	60	13	80	10	60	8	70	9	80	10
6	General level of education of the labor force	50	11	80	9	80	9	60	7	50	6
		450	100	91		63		64		68	

### 3. Quantitative Evaluation of Geosociological Factors

No.	FACTORS TO CONSIDER (In Order of Importance)	COUNTRIES UNDER CONSIDERATION									
		INDIA		ARGENTINA		GREECE		U. S. A.			
		Importance Value	Adjusted Importance Value	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating
1	Environmental conditions	100	37	90	33	90	33	70	26	50	19
2	Human traits	90	33	70	23	80	26	70	23	70	23
3	Production factors	80	30	80	24	70	21	60	18	40	12
		270	<del>100</del>		80		80		67		54

### 4. Quantitative Evaluation of the Degree of Capitalization of the Emerging Economy

1	Financial position of the economy	100	29	60	17	70	20	60	17	30	9
2	General level of industrialization	90	26	70	18	70	18	60	16	30	8
3	Relative degree of industrialization with respect to neighboring economies	80	24	80	19	80	19	70	17	40	10
4	Availability of international monetary aid	70	21	60	13	70	15	60	13	20	4
		340	100		67		72		63		31

# 5. Quantitative Evaluation of the Factors of Competition

No.	FACTORS TO CONSIDER (In Order of Importance)	COUNTRIES UNDER CONSIDERATION									
		INDIA		ARGENTINA		GRRECE		U..S. A.			
		Importance Value	Adjusted Importance Value	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating
1	Monopolistic industries	100	25	70	18	30	8	40	10	50	13
2	Level of local consumption	90	22	90	20	40	9	50	11	80	18
3	Production facilities	80	20	80	16	60	12	70	14	70	14
4	Competitive status of neighboring economies	70	18	60	11	50	9	80	14	90	16
5	Degree of industrial enterprise	60	15	60	9	50	8	50	8	90	14
		400	100		74		46		57		75

# 6. Quantitative Evaluation of the Extent of Engineering and Development

1	Agriculture-oriented or engineering-oriented economy	100	37	100	37	90	33	80	30	60	22
2	Degree of technological know-how	90	33	80	26	70	23	70	23	20	7
3	Indigenous manufacture of machinery	80	30	70	21	60	18	60	18	30	9
		270	100		84		74		71		38

# 7. Quantitative Evaluation of the Factor of Cost

No.	FACTORS TO CONSIDER (In Order of Importance)	COUNTRIES UNDER CONSIDERATION									
		INDIA		ARGENTINA		GREECE		U. S. A.			
		Importance Value	Adjusted Importance Value	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating	Evaluation Rating	Weighted Evaluation Rating
1	Capital available	100	14	90	13	80	11	80	11	40	6
2	Investment opportunities	95	13	70	9	80	10	70	9	100	13
3	Production capacity	90	13	80	10	60	8	60	8	70	9
4	Equipment availability	85	12	80	10	80	10	70	8	70	8
5	Labor cost	80	11	100	11	80	9	80	9	90	10
6	Changes in operating economics	75	10	60	6	30	3	40	4	100	10
7	Equipment purchase or lease	70	10	60	6	30	3	50	5	100	10
8	Equipment obsolescence	65	9	70	6	60	5	60	5	80	7
9	Equipment operating and maintenance cost	60	8	70	6	60	5	60	5	90	7
		720	100		77		64		64		80

Table 8. Synopsis of Quantitative Evaluation of Criteria

Criteria	Countries Under Consideration			
	India	Argentina	Greece	U. S. A.
	Weighted Evaluation Rating	Weighted Evaluation Rating	Weighted Evaluation Rating	Weighted Evaluation Rating
Political influence on the economy	88	90	81	26
Development in labor-management relations	91	63	64	68
Consideration of geo-sociological factors	80	80	67	54
Degree of capitalization of the emerging economy	67	72	63	31
Factors of competition	74	46	57	75
Extent of engineering and development	84	74	71	38
Factor of cost	77	64	64	80
TOTAL	561	489	467	372

### Interpretation of Results

From the Synopsis Tabulation, it can be seen that there is a dominant criterion in each of the different countries under review.

In the case of India, the most vital criterion is that of the "Development in Labor-Management Relations," for Argentina and Greece, it is that of the "Political Influence on the Economy," while for the United States it is the "Factor of Cost."

The study also indicates that some of the criteria are closely grouped in their quantitative rating and, therefore, the differentiation between them becomes subtle. The weighted evaluation ratings are arrived at from an entirely subjective approach and, therefore, represent projected estimates as to the degree of influence and importance of each criterion with respect to the other.

From the foregoing comparisons, it is now possible to subjectively establish a datum for determining a range over which the different levels of mechanization may be suitably adopted.

### Levels of Mechanization

Professor James R. Bright (4) has developed 17 levels of mechanization for production activities. These levels are:

1. Hand
2. Hand tool
3. Powered hand tool
4. Power tool, hand control
5. Power tool, fixed cycle
6. Power tool, program control

7. Power tool system, remote control
8. Actuation by introduction of workpiece
9. Measurement of a characteristic
10. Signalling selected values
11. Recording performance
12. Changing speed, position, or direction according to measurement
13. Segregating or rejecting according to measurement
14. Identifying and selecting appropriate action
15. Correcting performance after operating
16. Correcting performance while operating
17. Anticipating required performance and adjusting accordingly.

These levels of mechanization were adapted by Bazaraa (3) into 10 categories with particular reference to materials handling.

1. Hand
2. Hand equipment
3. Mechanized hand equipment
4. Gravity equipment
5. Power equipment, hand control
6. Power equipment, remote hand control
7. Power equipment, program control
8. Power equipment, feedback control
9. Adaptive system equipment
10. Fully automated system equipment

Since even 10 levels appear to be too many for the purpose intended here, the levels of mechanization can be further combined under

the following four major groups:

- I. Manual labor and/or hand equipment
- II. Mechanized equipment
- III. Power equipment
- IV. Automated equipment and sophisticated handling systems.

We must now formulate the Quantitative Evaluation of Criteria developed in relation to the four countries so as to arrive at a subjective scale of assessment through which it would be feasible to apportion each country its relevant level of mechanization in materials handling. Table 9 spotlights this.

#### Special Note

(i) From the tabulation it can be seen that, while the United States falls in the most advanced level of mechanization, the American spirit of national enterprise is so oriented that it strikes a judicious balance between the utilization of automated equipment and man power.

(ii) Similar subjective scales of interpretation can be formulated for determining the appropriate level of mechanization with regard to any given economy in the world.



Table 9. Equipment Selection at Different Levels of Mechanization

Country	Level of Mechanization	Overall Weighted Evaluation Rating x	Range of Mechanization $x \pm 5\%$	Type of Equipment
India	I	561	533 to 589	Manual labor and hand operated equipment
Argentina	II	489	464 to 514	Elementary mechanized equipment--(viz) conveyors, platform trucks
Greece	III	467	444 to 490	Powered equipment--(viz) electrically operated handling systems
U. S. A.	IV	372	353 to 391	Automated equipment--(viz) electronically controlled units and computerized systems of handling

## CHAPTER IX

### CONCLUSIONS AND RECOMMENDATIONS

The following important conclusions may be drawn with regard to the stipulation of the relevant criteria.

1. The social, cultural, political, climatological and geographical aspects of a developing economy must be closely examined in evaluating the choice of any materials handling system.
2. A quantitative appraisal of the criteria must be effected with a view to assigning a relative importance to each criterion. This analysis provides a directive to selecting the best solution.
3. Solutions should be sought in terms of capital-intensive versus labor-intensive concepts and sufficient accent must be placed on selecting that system of handling which is compatible with the characteristics of the country.
4. The most appropriate method need not necessarily be the optimum, nor the most advanced one. Care should be exercised in determining whether it would be more logical to employ the generally inexpensive and readily available labor potential, or to invest costly capital in the purchase of expensive equipment--the use of which would result in unemployment. In addition, there are, of course, more urgent uses for the limited supply of available capital.
5. A careful cost study should be conducted for choosing between prospective handling systems and due importance must be given to the

intangible factors involved herein.

6. As an overall conclusion to this thesis, it should be underscored that in many situations the policy of "full" employment provides a more judicious solution to the problem than the utilization of scarce financial resources for purchasing equipment, which would put people out of their daily livelihood.

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